

1 **WHAT IS CLAIMED IS:**

- 2 1. A method for finishing a metal article, comprising the steps of:
- 3 a) placing the metal article in a vibratory finishing apparatus, in combination
- 4 with:
- 5 i. a chemical solution capable of reacting with the surface of the metal article
- 6 to form a blackmode on the surface of the metal article, and
- 7 ii. a non-abrasive plastic media; and
- 8 b) agitating the metal article, the non-abrasive plastic media, and chemical
- 9 solution in the vibratory finishing apparatus so as to allow the non-abrasive
- 10 plastic media to remove the blackmode from the surface of the metal article,
- 11 thereby refining the surface of the metal article, after which the blackmode is
- 12 immediately re-formed by the reaction between the metal article and the
- 13 chemical solution for further refining by the non-abrasive plastic media, until
- 14 the metal article achieves a superfinished surface.
- 15 2. The method of claim 1, wherein the vibratory finishing apparatus is operated
- 16 at 800-1500 revolutions per minute at an amplitude of 1 to 8 millimeters.
- 17 3. The method of claim 1, wherein the chemical solution is added to the
- 18 vibratory finishing apparatus at a rate of 0.25-0.4 gallons per hour per cubic
- 19 foot volume of the vibratory finishing apparatus.
- 20 4. The method of claim 1, wherein the non-abrasive plastic media has a hardness
- 21 of about 57 on the Barcol scale.
- 22 5. The method of claim 1, wherein the non-abrasive plastic media comprises
- 23 about 50% by weight alumina bonded with an unsaturated polyester resin.
- 24 6. The method of claim 1, wherein the non-abrasive plastic media has a density
- 25 of about 1.8 g/cm³.
- 26 7. The method of claim 1, wherein the non-abrasive plastic media has a crystal
- 27 size of less than 0.9 mm.
- 28 8. The method of claim 1, wherein the chemical solution comprises a chemical
- 29 selected from the group consisting of phosphoric acid, phosphates, sulfamic
- 30 acid, oxalic acid, oxalates, sulfuric acid, sulfates, chromic acid, chromates,
- 31 bicarbonate, fatty acids, fatty acid salts, and combinations thereof.

- 1 9. The method of claim 8, wherein the chemical solution further comprises an
2 activator or accelerator selected from the group consisting of zinc,
3 magnesium, iron phosphates and combinations thereof.
- 4 10. The method of claim 8, wherein the chemical solution further comprises an
5 oxidizer, selected from the group consisting of inorganic oxidizer, organic
6 oxidizer, peroxides, meta-nitrobenzene, chlorate, chlorite, persulfates, nitrate,
7 nitrite compounds, and combinations thereof.
- 8 11. The method of claim 8, wherein the chemical is provided as a concentrate, and
9 is diluted with water to prepare the chemical solution, wherein the chemical is
10 diluted to between 5-80% by volume of the solution.
- 11 12. The method of claim 1, wherein the metal article comprises steel.
- 12 13. The method of claim 12, wherein the chemical solution comprises phosphates.
- 13 14. The method of claim 13, wherein the chemical solution is introduced into the
14 vibratory finishing apparatus at a rate of about 0.375 gallons per hour per
15 cubic foot volume of the vibratory finishing apparatus.
- 16 15. The method of claim 1, wherein the non-abrasive plastic media is cone
17 shaped.
- 18 16. The method of claim 1, wherein after the surface of the metal article has been
19 refined, a burnishing solution is introduced into the vibratory finishing
20 apparatus.
- 21 17. The method of claim 1 wherein the metal article comprises brass.
- 22 18. The method of claim 17, wherein the chemical solution is comprises hydrogen
23 peroxide and is maintained at a concentration at about 10% by volume.
- 24 19. The method of claim 18, wherein the chemical solution is introduced into the
25 vibratory finishing apparatus at a rate of about 0.4 gallons per hour per cubic
26 foot volume of the vibratory finishing apparatus.
- 27 20. The method of claim 1, wherein the rate of blackmode formation and removal
28 is balanced so that the blackmode is soft enough to allow the non-abrasive
29 plastic media to remove the blackmode from the surface of the metal article
30 and finish the metal article to an Ra of less than or equal to 2.5 microinches.
- 31 21. A method for finishing a metal article, comprising the steps of:

- 1 a) placing the metal article in a vibratory finishing apparatus, in combination
2 with:
3 i. a chemical solution capable of reacting with the surface of the
4 metal article to form a blackmode on the surface of the metal
5 article, and
6 ii. a non-abrasive metal media that is not reactive with the chemical
7 solution; and
8 b) agitating the metal article, the non-abrasive metal media, and chemical
9 solution in the vibratory finishing apparatus so as to allow the non-
10 abrasive metal media to remove the blackmode from the surface of the
11 metal article, thereby refining the surface of the metal article, after which
12 the blackmode is immediately re-formed by the reaction between the metal
13 article and the chemical solution for further refining by the non-abrasive
14 metal media, until the metal article achieves a superfinished surface.
- 15 22. The method of claim 21, wherein the non-abrasive metal media is selected
16 from the group consisting of stainless steel media, titanium alloys, nickel-
17 chromium alloys and combinations thereof.
- 18 23. The method of claim 21, wherein the vibratory finishing apparatus is operated
19 at 800-1500 revolutions per minute at an amplitude of 1 to 8 millimeters.
- 20 24. The method of claim 21, wherein the chemical solution is added to the
21 vibratory finishing apparatus at a rate of 0.25-0.4 gallons per hour per cubic
22 foot volume of the vibratory finishing apparatus.
- 23 25. The method of claim 21, wherein the shape of the non-abrasive metal media is
24 selected from the group consisting of pins, diagonals, ballcones, and mixtures
25 thereof.
- 26 26. The method of claim 21, wherein the chemical solution comprises a chemical
27 selected from the group consisting of phosphoric acid, phosphates, sulfamic
28 acid, oxalic acid, oxalates, sulfuric acid, sulfates, chromic acid, chromates,
29 bicarbonate, fatty acids, fatty acid salts, and combinations thereof.

- 1 27. The method of claim 26, wherein the chemical solution further comprises an
2 activator or accelerator selected from the group consisting of zinc,
3 magnesium, iron phosphates and combinations thereof.
- 4 28. The method of claim 26, wherein the chemical solution further comprises an
5 oxidizer, selected from the group consisting of inorganic oxidizer, organic
6 oxidizer, peroxides, meta-nitrobenzene, chlorate, chlorite, persulfates, nitrate,
7 nitrite compounds, and combinations thereof.
- 8 29. The method of claim 26, wherein the chemical is provided as a concentrate,
9 and is diluted with water to prepare the chemical solution, wherein the
10 chemical is diluted to between 5-80% by volume of the solution.
- 11 30. The method of claim 21, wherein the metal article comprises steel.
- 12 31. The method of claim 30, wherein the chemical solution comprises oxalic acid.
- 13 32. The method of claim 30, wherein the chemical solution is introduced into the
14 vibratory finishing apparatus at a rate of about 0.625 gallons per hour per
15 cubic foot volume of the vibratory finishing apparatus.
- 16 33. The method of claim 21, wherein after the surface of the metal article has
17 been refined, a burnishing solution is introduced into the vibratory finishing
18 apparatus.
- 19 34. The method of claim 21 wherein the non-abrasive metal media that is not
20 reactive with the chemical solution is combined with a non-abrasive plastic
21 media.
- 22 35. The method of claim 21, wherein the rate of blackmode formation and
23 removal is balanced so that the blackmode is soft enough to allow the non-
24 abrasive metal media to remove the blackmode from the surface of the metal
25 article and finish the metal article to an Ra of less than or equal to 2.5
26 microinches.